Original Article

Comparative Efficacy of Multiplane Force Application and Ischemic Compression on Masticatory Muscles: A Randomized Controlled Trial

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Objective: To compare the immediate effect between the multiplane force application (MFA) and ischemic compression (IC) techniques on pain alteration and the activity of masticatory muscles.

Materials and Methods: Eighty-six participants who had latent myofascial trigger points (LTrPs) in either masseter or temporalis muscle, from 18 to 60 years of age, were recruited into this study. Participants were randomly assigned into two groups. Group I (n = 43) received the MFA technique, whereas group II (n = 43) received the IC technique. In each group, the muscles with LTrPs were treated for 30 min. Outcome measures including pressure pain threshold (PPT) and resting muscle activity were assessed at pre-treatment and post-treatment. Significant differences of selected outcomes within groups were analyzed by paired t-test. To compare the differences between groups, an independent t-test was used.

Results: PPT of masseter and anterior temporalis muscles were increased and the resting muscle activity was reduced significantly at the post-treatment period ($p<0.001$) in both IC and MFA groups. There was no significant difference in changes in PPTs and resting EMG between both techniques ($p>0.05$).

Conclusion: The two methods have similar efficiency for increasing PPT and reducing resting activity of the masseter and anterior temporalis muscles.

Keywords: Multiplane force application technique, Ischemic compression technique, Latent myofascial trigger point, Manual therapy

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Temporomandibular disorder (TMD) is a group of complex chronic disorder which involves pain or adysfunction of the temporomandibular joint and/or masticatory muscles[1]. Due to the complexity of its pathophysiology, different treatment modalities are used by a multidisciplinary team such as dentists, orthodontists, psychologists, physicians, and physical therapists[2].

Many procedures in physical therapy including ultrasound, thermotherapy (heat and cold), massage, exercise, and manual therapy have been used to treat TMD in order to reduce pain, increase flexibility, and improve temporomandibular joint functions[3]. Although physical therapy is effective and commonly used in treating TMD, none of the techniques could be referred as standard treatment due to a small number of randomized controlled trials[4].

IC is a commonly used technique in the management of TMD, especially for trigger point release. The technique is performed by sustained compression at the myofascial trigger points, usually for 60 to 90 seconds in each point[5]. Vernon and Schneider reported that IC could relieve pain at the trigger point in patients with myofascial pain syndrome[6]. Moreover, IC could improve blood circulation and increase tissue flexibility[7,8]. Pain is usually reported as the adverse effect of IC due to its sustained force application. Therefore, therapists should be careful when using IC in small muscles, such as masticatory muscles.

The multiplane force application (MFA) was developed by Boonprakob and coworkers based on the tensegrity principle, which is described transmission forces on multiple layers of myofascial components[9-11]. With this technique, physical therapists apply cyclic compression, tension, and shearing forces, respectively. The force is applied gently to the muscle tissue around the trigger point. In this study, we investigated whether MFA could be used

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in treating latent trigger point pain in masticatory muscles. Changes in pain pressure threshold and resting muscle activity were investigated in both MFA and IC techniques.

Objective

The objective of the study was to compare the immediate effect of MFA and IC techniques on pain alteration and the resting activity of masticatory muscles in healthy participants.

Design and setting

This study was a double-blinded, randomized controlled trial (blinded assessor and participants) which was conducted in the Orofacial Pain Clinic, Faculty of Dentistry, Khon Kaen University. Ethical approval for the study was granted by the Khon Kaen University Ethics Committee (HE582205). The study was registered in the Thai Clinical Trials Registry (TCTR20180121002).

Study subjects

Eighty-six healthy participants were recruited in this study. Inclusion criteria were participants (1) aged from 18 to 60 years, (2) presented with latent myofascial trigger points (LTrPs) of masseter and anterior temporalis muscles The presence of LTrPs was determined using the diagnostic criteria described by Simons and coworkers[12], and (3) with previous history of masticatory muscle pain. Exclusion criteria were participants with (1) degenerative TMJ diseases (2) history of traumatic injury or accident at the cervical spine or TMJ (e.g. contusion, fracture, and whiplash injury) within six months prior to participation, (3) prior surgery at the cervical spine or TMJ, (4) neurological disorders of head and neck (e.g. trigeminal neuralgia), (5) fibromyalgia and (6) cancer.

Materials and Methods

Participants were randomly allocated to MFA or IC groups using a computer-generated false-random-number method. Participants in group I were treated with MFA technique (n = 43) whereas those in group II were treated with IC technique (n = 43). Both techniques were applied at the most painful LTrPs on the affected muscles. During each procedure, the masseter muscle was treated first for 15 minutes followed by the anterior temporalis muscle for another 15 minutes. This study was a double blind randomized controlled trial study (RCT), which the assessor and participants were blinded. The assessor and therapist were different persons.

MFA group

The therapist fixed the origin or insertion point of the affected muscle with one hand and the other hand was used to apply the therapeutic loading, including compression, tension, and shearing, respectively. The cyclic loading was applied ‘around’ the LTrPs in a pain free manner. The duration of treatment was 30 minutes (90 seconds/set and 9 sets/triggered point) (Figure 1).

IC group

The therapist applied sustained compression at the LTrPs with the thumb within the pain tolerance level. The duration of force application ‘in’ each triggered point was 90 seconds for 9 sets/point[13-16] (Figure 2). To control the force, a FlexiForce® sensor (FSR402 sensor (Force Sensing Resistor® Technology, USA) was attached to the therapist’s thumb (Figure 3) and connected to the data acquisition system (MP100, Biopac Systems, Goleta, CA, USA) for force display. The initial force was maintained and increased gradually. The amount of force was limited to 3 kg/cm^2[12] in order to prevent adverse effect including pain or inflammation.

Outcome measures

Pain alteration was assessed by pressure pain threshold (PPT). The resting activity of masseter and anterior temporalis muscles was also measured in the jaw’s rest

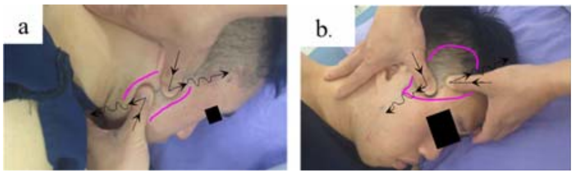

Figure 1. MFA technique on a) masseter and b) anterior temporalis muscles.

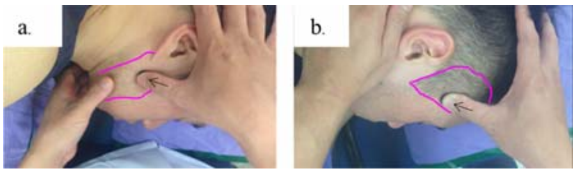

Figure 2. IC technique on a) masseter and b) anterior temporalis muscles.

Figure 3. A force sensor is fastened to the therapist’s thumb.

position using surface electromyography. Both outcome measures were assessed at baseline and after treatment immediately. The details of the measurements were described below.

PPT

PPT was measured by a digital algometer (Wagner Force One™ Model FDIX; wagner Instruments, Greenwich, CT, USA), with a force range between 0 to 10 kg, to assess the most painful trigger point. PPT measurement was expressed in kg/cm². During the assessment, the participant was in a supine position. The most painful trigger point in each muscle was located and marked with a non-permanent marker[18]. The measurement was repeated three times by the same assessor.

Resting muscle activity

The skin over the affected side of the anterior temporalis and masseter muscles were prepared to reduce inter-electrode impedance and increase the signal-to-noise ratio by rubbing the skin with a 70% alcohol solution. Silver-silver chloride (Ag/AgCl) electrodes (Duotrode, Myotronics, Kent, WA, USA) with a center-to-center inter-electrode distance of 19 mm were placed at the central part of the muscles, parallel to the muscular fibers. A ground electrode was placed over the participant's forehead. Snap leads were used to connect the surface electrodes to the EMG amplifier (EMG100; Biopac Systems, Goleta, CA, USA). A signal acquisition unit (MP 100; Biopac Systems, Goleta, CA, USA) and an acquisition software (Acknowledge 1.0) were used to record the resting EMG signals. The sampling rate was 1,000 Hz with a signal amplification of 1,000. The common mode rejection ratio was 110 dB and the frequency bandwidth was 10 to 500 Hz. The raw EMG signal was rectified and smoothed to obtain integrated EMG.

For all participants, the activities of the anterior temporalis and masseter muscles were recorded in the rest position in an air-conditioned room (25°C). The participants were in supine position with their mouth open to 1 cm in order to relax jaw closing muscles[20]. Resting EMG signals were recorded for 2 minutes and a 20-second window of the integrated EMG signal was chosen from the middle part of the whole record for analysis.

Sample size

Sample size was calculated by utilizing the values of PPT from the study of Kim et al[21]. Mean difference of the PPT between the two groups was set at 1.74 kg/cm². The significance level of 5% and the power of the test of 80% were used in the calculation. According to the calculation, the required participants were 86.

Statistical analysis

The outcome measures were analyzed and presented as mean $\pm$ standard deviation (SD) for the continuous variables and percentage for the category variables. A paired t-test was used to compare the outcome variables between baseline and post-treatment. To compare the differences between groups, an independent t-test was used. The analyses were performed using SPSS version 17 (IBM, Armonk, NY, USA), $p<0.05$ was considered statistically significant.

Results

Of the 86 participants with LTrPs, 72 were females (83.7%) and 14 were males (16.3%). The MFA group consisted of 37 females and 6 males with a mean age of 33.8±11.3 years while the IC group consisted of 35 females and 8 males with a mean age of 34.2±12.6 years. The baseline characteristics were equally balanced between the two groups and showed no statistically significant differences between groups ($p>0.05$). The demographic data of the outcome measurements at baseline are summarized in Table 1 and 2, respectively.

Effect of MFA and IC on all outcomes

The baseline and post-treatment PPT and resting muscle activity showed a significant difference ($p<0.001$), indicating a significant increase in pain threshold level and a reduction of resting muscle activity for both groups (Table 3). The comparison between groups showed no significant difference of both outcomes in the PPT and resting EMG ($p>0.05$; Table 4).

Discussion

This study is the first research to prove the efficacy of MFA on the latent trigger point which is a novel form of manual therapy. Its effective procedure for improving PPT

Table 1. Demographic data of participants

Characteristics	MFA group (n = 43)	IC group (n = 43)	*p*-value
Female, n (%)	37 (86.1)	35 (81.4)	0.18
Age (yr), mean ± SD	33.8±11.3	34.2±12.6	0.88
Weight (kg), mean ± SD	60.6±10.9	58.3±10.1	0.31
Height (cm), mean ± SD	158.9±17.6	161.4±9.3	0.40
LTrP in right side, n (%)	23 (53.5)	19 (44.9)	0.19
Right-handed participants, n (%)	38 (88.4)	36 (83.7)	0.53

MFA = multiplane force application technique; IC = ischemic compression technique

Table 2. Outcome variables measurement at baseline

Characteristics	MFA group (n = 43)	IC group (n = 43)	*p*-value
PPT, kg/cm^2			
MA	0.82±0.23	0.81±0.23	0.71
AT	0.79±0.24	0.91±0.28	0.06
Resting EMG, µV			
MA	0.39±0.08	0.41±0.10	0.64
AT	0.69±0.12	0.70±0.10	0.92

MA = masseter muscle, AT = anterior temporalis, PPT = pressure pain threshold

Table 3. Comparison of PPT and resting activity of masseter and anterior temporalis muscles between baseline and post-treatments in MFA and IC groups

Outcomes	MFA (n = 43)	*p*-value	Mean difference (95% CI)	IC (n = 43)	*p*-value	Mean difference (95% CI)
PPT, kg/cm^2						
MA, mean ± SD						
Baseline	0.82±0.23	0.001*	0.49	0.81±0.23	0.001*	0.46
Post-treatment	1.31±0.50		(0.36 to 0.60)	1.27±0.41		(0.35 to 0.57)
AT, mean ± SD						
Baseline	0.79±0.24	0.001*	0.57	0.91±0.28	0.001*	0.45
Post-treatment	1.36±0.64		(0.37 to 0.75)	1.36±0.43		(0.33 to 0.56)
Resting activity, µV						
MA						
Baseline	0.39±0.08	0.001*	0.07	0.41±0.10	0.001*	0.07
Post-treatment	0.32±0.09		(0.05 to 0.09)	0.34±0.10		(0.05 to 0.08)
AT, mean ± SD						
Baseline	0.69±0.12	0.001*	0.04	0.70±0.10	0.001*	0.06
Post-treatment	0.65±0.11		(0.03 to 0.05)	0.64±0.08		(0.04 to 0.07)

MA = masseter muscle, AT = anterior temporalis, PPT = pressure pain threshold
$p<0.05$ or * = statistically significant differences from pre-treatment

Table 4. Comparison of PPT and resting activity of masseter and anterior temporalis muscles between MFA and IC groups immediately after treatment

Outcomes	MFA vs. IC groups		
	Mean difference	95% CI	*p*-value
PPT, kg/cm^2			
MA	0.04	-1.38 to 1.70	0.07
AT	0.00	-0.24 to 0.33	0.97
Resting activity, □V			
MA	0.02	- 0.05 to 0.03	0.47
AT	0.01	-0.02 to 0.06	0.38

MA = masseter muscle, AT = anterior temporalis, MFA = multiplane force application technique, IC = ischemic compression technique, PPT = pressure pain threshold

and reducing the resting activity of masticatory muscles when compare with IC.

The effect of MFA and IC techniques on PPT

The present study demonstrated that both MFA and IC techniques could similarly increase PPT, suggesting that MFA and IC might be used interchangeably. IC techniques used a static compression on the trigger point whereas MFA relied on a sequence of compression, tension, and shearing force around the trigger point. It has been shown that the myofascial trigger point could be relieved by manual therapy[9,22], such as strain-counter-strain, myofascial release, and western massage techniques. Manual therapy can improve blood circulation, relieve pain, and increase mouth opening in patients with TMD[17,23]. Various theories have been proposed to explain the effect of manual therapy on pain reduction including gate control theory[24] and descending inhibitory pathway[25,26].

According to the gate control theory, the force used during MFA might stimulate large-diameter myelinated nerve fibers and suppress pain transmission. The comfortable touch might also trigger stimulate the descending pathway and induce releasing of endogenous opioid mediators for pain reduction[18,27,28]. Previous studies showed the placebo effect of touch which could reduce pain similar to manual therapy[29-32]. In addition, the cyclic nature of force application in MFA might also improve the perfusion of muscle spindles[33], resulting in the removal of inflammatory mediators[28].

IC produces temporary local ischemia and follow by reactive hyperemia and increase blood circulation after released pressure[12], leading to relief pain and reduces muscle spasm[34]. A previous study showed a similar effect of IC and passive stretching on pain reduction of myofascial trigger points of the trapezius muscle in patients with myofascial pain syndrome[35].

The effect of MFA and IC techniques on resting muscle activity

The resting muscle activity could be used to monitor muscle hypertonicity in patients with TMD[36]. It is also used for assessment of muscle pain indirectly[37-39]. In this study, the resting muscle activity could be supported VAS and PPT for pain assessment. Hypertonicity of masticatory muscles at rest was shown in masticatory muscle pain[40-42]. Resting muscle activity could also reflect muscle relaxation and has been shown to be reduced after manual therapy. The current study found that resting activity of the affected muscle was reduced significantly compared to baseline both in MFA and IC groups. The reduction of resting muscle activity found in this study ranged from 5.8 to 17.9% which was comparable to the effect of occlusal splint in patients with sleep bruxism reported by Amorim et al[43]. According to the energy crisis theory, the persistence of MTrPs is associated with low blood oxygen at the trigger point which disturbs the relaxation phase of muscle physiology[18,27]. MFA and IC techniques may enhance blood flow and encourage muscle relaxation at the trigger point. Increasing the oxygen supply is believed to enhance aerobic respiration in muscular tissue. Relaxation of the trigger point nodule enables blood flow to the tissue. This allows for increased substrate perfusion and oxygen delivery to skeletal muscle to meet the cellular energy demands required to regain homeostasis[44,45].

This study is carried out in limited the effectiveness of MFA technique in musculoskeletal problem such as TMDs patients. Moreover, there are not assessing the short and long term effect of these treatments. So, it needs further studies to emphasize the findings.

Conclusion

In patients with latent muscle trigger points, MFA and IC were similarly effective for pain reduction and possibly decreasing hypertonicity of masticatory muscles. Therefore, both types of manual therapy could be applied interchangeably. However, MFA seemed to be preferable since the technique did not provoke muscle pain during the manipulation.

What is already known on this topic?

This is the comparative study of therapeutic effect between the multiplane force application (MFA) technique and ischemic compression (IC) technique on masticatory muscles in healthy participants. The results could be concluded as follows:

1) MFA and IC can increase pressure pain threshold similarly on latent trigger points of masseter and temporalis muscles.

2) MFA and IC can decrease muscle activity of masseter and temporalis muscles similarly using by sEMG.

What this study adds?

The aims to compare the therapeutic effect between the multiplane force application (MFA) technique and ischemic compression (IC) technique on masticatory muscles in healthy participants.

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Potential conflicts of interest

The authors declare no conflicts of interest.

References

1. McNeill C. Management of temporomandibular disorders: concepts and controversies. J Prosthet Dent 1997;77:510-22.
2. Okeson JP. Management of temporomandibular disorders and occlusion. 5th ed. St. Louis: Mosby; 2003.
3. Medlicott MS, Harris SR. A systematic review of the effectiveness of exercise, manual therapy, electrotherapy, relaxation training, and biofeedback in the management of temporomandibular disorder. Phys Ther 2006;86:955-73.
4. Armijo-Olivo S, Pitance L, Singh V, Neto F, Thie N, Michelotti A. Effectiveness of manual therapy and therapeutic exercise for temporomandibular disorders: Systematic review and meta-analysis. Phys Ther 2016;96:9-25.
5. Wright EF. Manual of temporomandibular disorders. 2nd ed. Ames, IA: Blackwell; 2010.
6. Vernon H, Schneider M. Chiropractic management of

myofascial trigger points and myofascial pain syndrome: a systematic review of the literature. J Manipulative Physiol Ther 2009;32:14-24.
7. Aguilera FJ, Martin DP, Masanet RA, Botella AC, Soler LB, Morell FB. Immediate effect of ultrasound and ischemic compression techniques for the treatment of trapezius latent myofascial trigger points in healthy subjects: a randomized controlled study. J Manipulative Physiol Ther 2009;32:515-20.
8. Simons DG, Hong CZ, Simons LS. Endplate potentials are common to midfiber myofacial trigger points. Am J Phys Med Rehabil 2002;81:212-22.
9. Fernandez-de-Las-Penas C, Cleland J, Dommerholt J. Manual therapy for musculoskeletal pain syndromes. London: Elsevier; 2015.
10. Langendoen J, Muller J, Jull GA. Retrodiscal tissue of the temporomandibular joint: clinical anatomy and its role in diagnosis and treatment of arthropathies. Man Ther 1997;2:191-8.
11. Joshi DG, Balthillaya G, Prabhu A. Effect of remote myofascial release on hamstring flexibility in asymptomatic individuals - A randomized clinical trial. J Bodyw Mov Ther 2018;22:832-7.
12. Simons DG, Travell JG, Simons LS. Travell & Simons' Myofascial pain and dysfunction: The trigger point manual. 2nd ed. Baltimore: Williams and Wilkins; 1999.
13. Whitney WL. Orthopedic massage: theory and technique. 2nd ed. Edinburgh: Mosby; 2009.
14. Manfredini D. Current concepts on temporomandibular disorders. London: Quintessence; 2010.
15. Hou CR, Tsai LC, Cheng KF, Chung KC, Hong CZ. Immediate effects of various physical therapeutic modalities on cervical myofascial pain and trigger-point sensitivity. Arch Phys Med Rehabil 2002;83:1406-14.
16. Nagrale AV, Glynn P, Joshi A, Ramteke G. The efficacy of an integrated neuromuscular inhibition technique on upper trapezius trigger points in subjects with non-specific neck pain: a randomized controlled trial. J Man Manip Ther 2010;18:37-43.
17. La Touche R, Paris-Alemany A, Mannheimer JS, Angulo-Diaz-Parreno S, Bishop MD, Lopez-Valverde-Centeno A, et al. Does mobilization of the upper cervical spine affect pain sensitivity and autonomic nervous system function in patients with cervico-craniofacial pain?: A randomized-controlled trial. Clin J Pain 2013;29:205-15.
18. Fernandez-de-Las-Penas C, Alonso-Blanco C, Cuadrado ML, Gerwin RD, Pareja JA. Myofascial trigger points and their relationship to headache clinical parameters in chronic tension-type headache. Headache 2006;46:1264-72.
19. Oncins MC, Vieira MM, Bommarito S. Electromyography of the masticatory muscles: analysis in the original and RMS value. Revista CEFAC 2014;16:1215-21.
20. Manns A, Miralles R, Guerrero F. The changes in electrical activity of the postural muscles of the mandible upon varying the vertical dimension. J Prosthet Dent 1981;45:438-45.
21. Kim SA, Oh KY, Choi WH, Kim IK. Ischemic compression after trigger point injection affect the treatment of myofascial trigger points. Ann Rehabil Med 2013;37:541-6.
22. Hanten WP, Olson SL, Butts NL, Nowicki AL. Effectiveness of a home program of ischemic pressure followed by sustained stretch for treatment of myofascial trigger points. Phys Ther 2000;80:997-1003.
23. Eisensmith LP. Massage therapy decreases frequency and intensity of symptoms related to temporomandibular joint syndrome in one case study. J Bodyw Mov Ther 2007;11:223-30.
24. Melzack R, Wall PD. Pain mechanisms: a new theory. Science 1965;150:971-9.
25. Wright A. Hypoalgesia post-manipulative therapy: a review of a potential neurophysiological mechanism. Man Ther 1995;1:11-6.
26. Vicenzino B, Collins D, Benson H, Wright A. An investigation of the interrelationship between manipulative therapy-induced hypoalgesia and sympathoexcitation. J Manipulative Physiol Ther 1998;21:448-53.
27. Huguenin LK. Myofascial trigger points: the current evidence. Phys Ther Sport 2004;5:2-12.
28. King HH, Janig W, Patterson MM. The science and clinical application of manual therapy. Edinburgh: Churchill Livingstone; 2011.
29. Bialosky JE, Bishop MD, George SZ, Robinson ME. Placebo response to manual therapy: something out of nothing? J Man Manip Ther 2011;19:11-9.
30. Khamboon T. Touch power: healing power from body through mind. Nurs J 2008;35:77-85.
31. Moraska AF, Stenerson L, Butryn N, Krutsch JP, Schmiege SJ, Mann JD. Myofascial trigger point-focused head and neck massage for recurrent tension-type headache: a randomized, placebo-controlled clinical trial. Clin J Pain 2015;31:159-68.
32. Toro-Velasco C, Arroyo-Morales M, Fernandez-de-Las-Penas C, Cleland JA, Barrero-Hernandez FJ. Short-term effects of manual therapy on heart rate variability, mood state, and pressure pain sensitivity in patients with chronic tension-type headache: a pilot study. J Manipulative Physiol Ther 2009;32:527-35.
33. Partanen JV, Ojala TA, Arokoski JP. Myofascial syndrome and pain: A neurophysiological approach. Pathophysiology 2010;17:19-28.
34. Wall PD, Melzack R. Textbook of pain. Edinburgh: Churchill Livingstone; 1984.
35. Kostopoulos D, Nelson AJ Jr, Ingber RS, Larkin RW. Reduction of spontaneous electrical activity and pain perception of trigger points in the upper trapezius muscle through trigger point compression and passive stretching. J Musculoskelet Pain 2008;16:266-78.
36. Ardizone I, Celemin A, Aneiros F, del Rio J, Sanchez T, Moreno I. Electromyographic study of activity of the

masseter and anterior temporalis muscles in patients with temporomandibular joint (TMJ) dysfunction: comparison with the clinical dysfunction index. Med Oral Patol Oral Cir Bucal 2010;15:e14-9.

37. Simons DG. Review of enigmatic MTrPs as a common cause of enigmatic musculoskeletal pain and dysfunction. J Electromyogr Kinesiol 2004;14:95-107.
38. Nishi SE, Basri R, Alam MK. Uses of electromyography in dentistry: An overview with meta-analysis. Eur J Dent 2016;10:419-25.
39. Litcher-Kelly L, Martino SA, Broderick JE, Stone AA. A systematic review of measures used to assess chronic musculoskeletal pain in clinical and randomized controlled clinical trials. J Pain 2007;8:906-13.
40. Lodetti G, Marano G, Fontana P, Tartaglia GM, Maria de Felicio C, Biganzoli E, et al. Surface electromyography and magnetic resonance imaging of the masticatory muscles in patients with arthrogenous temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol 2014;118:248-56.
41. Roark AL, Glaros AG, O'Mahony AM. Effects of interocclusal appliances on EMG activity during parafunctional tooth contact. J Oral Rehabil 2003;30:573-7.
42. Kamyszek G, Ketcham R, Garcia R Jr, Radke J. Electromyographic evidence of reduced muscle activity when ULF-TENS is applied to the Vth and VIIth cranial nerves. Cranio 2001;19:162-8.
43. Amorim CF, Vasconcelos Paes FJ, Faria Junior NS, de Oliveira LV, Politti F. Electromyographic analysis of masseter and anterior temporalis muscle in sleep bruxers after occlusal splint wearing. J Bodyw Mov Ther 2012;16:199-203.
44. Bashir F, Kumar P, Gopal K. Effect of combined manual therapy techniques with modalities on pain and discomfort of patients with fibromyalgia syndrome. Gulf Medical Journal 2012;1 Suppl 2:S189-92.
45. Capellini VK, de Souza GS, de Faria CR. Massage therapy in the management of myogenic TMD: a pilot study. J Appl Oral Sci 2006;14:21-6.